

Vascular access in previously catheterised children and adolescents: a prospective study of 131 consecutive cases

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Abstract

Background—Vascular access for cardiac catheterisation of children and young adults who have had previous catheter procedures is often difficult.

Objective—To assess the influence of age at and type and technique of previous cardiac catheterisation on the ease of vascular access for subsequent study of paediatric and adolescent patients.

Setting—Tertiary referral centre for paediatric cardiology.

Patients—478 Consecutive patients aged 1 day to 19 years undergoing cardiac catheterisation over a 12 month period, including 131 patients who had had previous catheterisation(s).

Methods—Prospective study, recording for each patient the age, weight, diagnosis, vascular access (artery, vein, or both), vessels eventually catheterised, access time, total duration of the procedure, and details of any previous catheter studies.

Results—Of 131 patients who had had previous catheterisations, 80 (61%) had been studied once previously, 38 (29%) twice, and 13 (10%) on three or more occasions. The right femoral vessels were cannulated without difficulty in 72 cases (55%). Elective cannulation of left femoral vessels (because of scar tissue on the right side) or upper body vessels was undertaken in 18 cases (14%). Problems cannulating the right femoral vessels were encountered in 41 cases (31%); the vein was blocked in 29, the artery in six and the femoral veins were blocked bilaterally in six cases. The mean (SD) access time was significantly prolonged in these 41 children (41(18) v 21(13) minutes, $p < 0.001$) as was total duration of the procedure (116(31) v 94(34) minutes, $p < 0.001$). Children who had had a saphenous vein cut down as neonates subsequently had a blocked ipsilateral femoral vein in 10/15 cases (67%). Risk factors for problematic cannulation also included a higher number of previous catheterisation procedures.

Conclusions—Difficulties with vascular access are common in children and adolescents who have had previous cardiac catheterisations. In those who have had cut down or multiple previous studies, elective entry to the left femoral vessels should be undertaken and procedure time may be prolonged. Such cases

should therefore be performed under general anaesthesia.

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Percutaneous insertion of catheters into arteries and veins was first described in 1953¹ and since then cardiac catheterisation has become important in diagnosis and treatment of children with heart disease. The femoral approach is used routinely in most centres.² With advances in palliative and corrective surgical techniques and improved medical treatments, more children with heart disease are surviving long enough to require repeat cardiac investigations. The indications for repeat catheterisation include investigation of patients with residual defects after definitive repair, investigation before staged surgery for complex defects, and interventional procedures. This is the first prospective study to investigate the practical issue of difficult vascular access in these subjects with congenital heart disease.

Patients and methods

The study group comprised 478 consecutive patients undergoing diagnostic (352) or interventional (126) cardiac catheterisation at our hospital during the 12 months from 1 September 1991 to 31 August 1992. For each case a record was made of the age, weight, diagnosis, time from patient lying on the catheter table until all the necessary vessels (artery, vein, or both) were catheterised (access time), and the total time for the procedure. The vessels successfully catheterised were recorded. The case notes were examined for details of all previous catheter studies. The control group comprised 100 randomly selected patients that were catheterised for the first time during the study period.

At our hospital routine diagnostic catheterisation is performed under sedation and local anaesthesia; perioperative and interventional cases are performed under general anaesthesia, and the percutaneous approach of first choice is through the right femoral vessels. Indication for catheter study was determined by the consultant physician. The routine use of heparin (100 U/kg intravenously) for arterial studies started here in 1968. Failed vascular access was defined as either prolonged effort by an experienced operator (at least 20

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minutes for artery or vein) or angiographic proof of a blocked vessel.

Descriptive statistics are reported as mean (SD). Data from recatheterised patients were compared with control data by unpaired Student's *t* test and statistical significance was inferred at *p* < 0.05. Risk factors for failed vascular access were analysed in a multivariate logistic regression model.

Results

Of the 478 children undergoing catheterisation in the 12 month study period, 131 (72 boys, 59 girls) aged 1 day to 19 years (median 6.5 years), including 26 teenagers, had had at least one previous catheter study (27%). Eighty of these (61%) had had one previous study, 38 (29%) had been studied twice previously, eight (6%) three times, one four times, two five times, and two on six previous occasions. Twenty two had previously had an interventional catheter (balloon atrial septostomy in 18, balloon for extracardiac conduit stenosis in two, and for aortic coarctation

in two cases). These 131 patients were significantly older than the control group of children undergoing their first catheterisation (88(65) *v* 38(48) months, *p* < 0.001). Over the 12 month study period there were no deaths related to the catheterisations.

In the control group, right femoral vascular access was successful in 98/100 children, with access time 23(14) minutes. In two cases (one neonate, one child) the right femoral vein could not be cannulated despite prolonged effort and the left femoral vein was catheterised percutaneously. By contrast, right femoral vascular access was successful in only 72/131 children (55%) who had previously been catheterised, with access time 21(13) minutes (NS compared with controls). In 18 cases (15%), vessels other than the right femoral vessels were electively catheterised; in 15 cases the left femoral vessels, because of perceived scar tissue on the right side, in one case the right subclavian vein and in another the jugular vein was used to study the superior vena caval connections in patients after operation, and in one case access was through the left axillary artery for coil embolisation of a systemic to pulmonary artery shunt. Access time in these 18 cases was 22(12) minutes (NS compared with controls). In 41/131 cases (31%) there was difficulty with attempted cannulation of the right or left femoral vessels (table). In 29 cases the right femoral vein could not be catheterised (angiographic proof of blockage in 11; fig 1) and the left femoral vein was used. In six cases (including four teenagers) the right femoral artery could not be catheterised (angiographic proof of blockage in two cases), and in six cases the femoral veins were blocked bilaterally. These six patients had all been catheterised at least twice before, and two had been catheterised six times each previously. Access was obtained through the right subclavian vein (four cases) or the case was completed by retrograde arterial catheterisation only. In no case was a cut down procedure undertaken. The access time for these 41 procedures was significantly prolonged (41(18) min, *p* < 0.001 compared with controls).

Thirty two of 131 children (24%) had been catheterised in the neonatal period. Of the 15 who had undergone balloon atrial septostomy for transposition of the great arteries, seven had had a saphenous vein cut down procedure and eight had had a femoral vein percu-

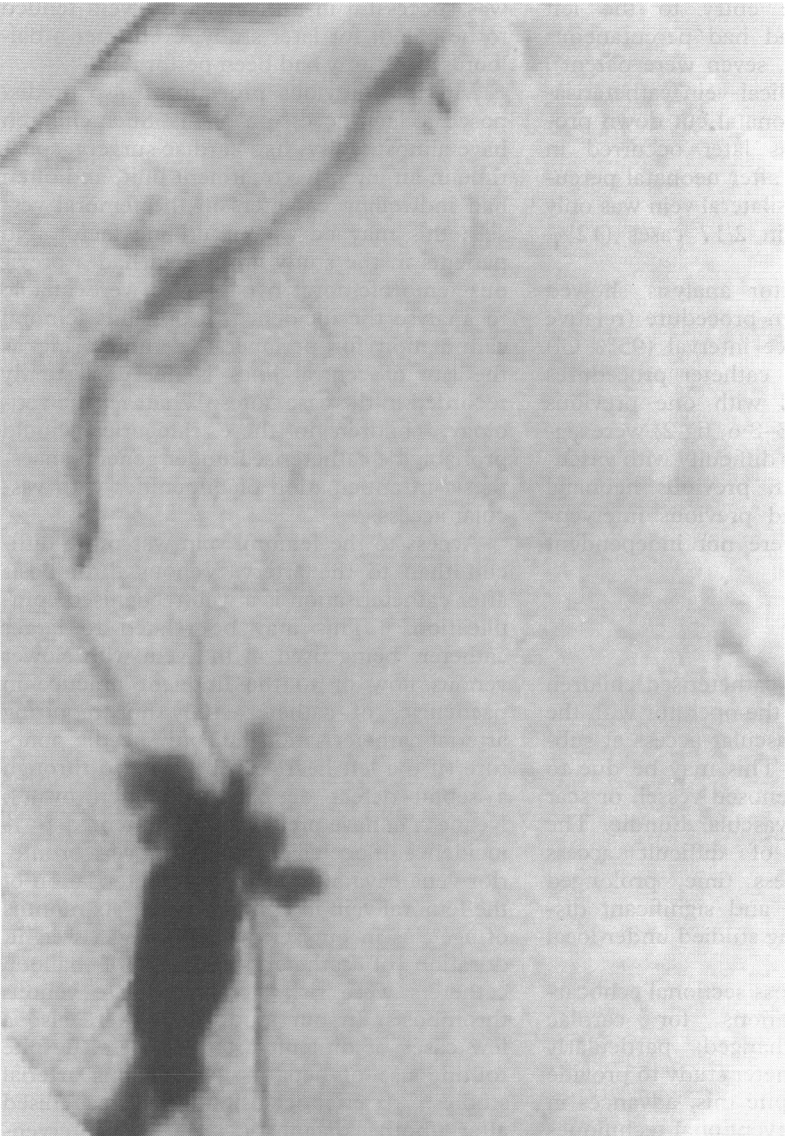


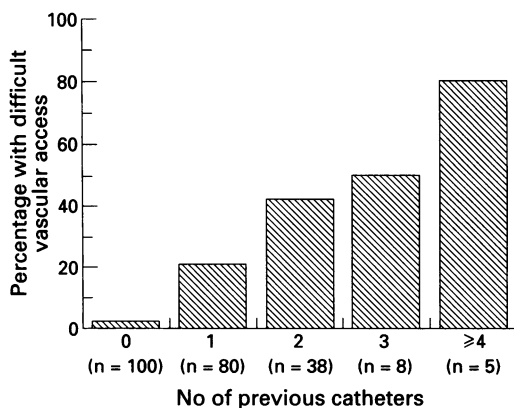
Figure 1 Digital subtraction angiogram from a two year old boy who had had one previous catheter study as an infant, showing blocked right femoral vein and single collateral.

Vascular access obtained in 131 children who had previous cardiac catheterisation (values are means (SD))

Vessels catheterised	No	Access time (min)	Procedure time (min)
RFV, RFA, or both	72 (55%)	21 (13)	94 (34)
Other elective†	18 (14%)	22 (12)	84 (26)
Difficult access‡	41 (31%)	41 (18)***	116 (31)***

****p* < 0.001 compared with both other groups.
†Elective use of LF vessels (15) because of perceived scar tissue on right side, or use of other vessels (3) to study upper body veins in patients after Glenn shunt, or for interventions.
‡RFV entry, RFA entry, or both failed. Includes six cases with LFV also blocked.
FA, femoral artery; FV, femoral vein; L, left; R, right.

Figure 2 The relation between number of previous catheter procedures and the incidence of difficult femoral vascular access in 100 controls and 131 previously catheterised children and adolescents.



taneous approach. The ipsilateral femoral vein was later impossible to cannulate in 5/7 (71%) who had had cut down procedures, and patent in two (29%); by contrast in those who had had percutaneous entry, the vein was later blocked in 1/8 (13%) and patent in seven (87%). Of 17 children who had undergone neonatal catheterisations without balloon septostomy, eight had had a cut down (five cases were blocked subsequently, two were patent, and one was not known because of subsequent elective entry to the left femoral vein), eight had had percutaneous entry (one was blocked, seven were patent), and one had had umbilical vein catheterisation. Therefore after neonatal cut down procedures, difficult access later occurred in 10/15 cases (67%), but after neonatal percutaneous approach the ipsilateral vein was only difficult to catheterise in 2/17 cases (12%, $p < 0.01$).

Multivariate risk factor analysis showed that a previous cut down procedure (relative risk 4.8, 95% confidence interval (95% CI) 1.3–17.7) and multiple catheter procedures (relative risk compared with one previous catheter 2.7, 95% CI 1.3–8.6, fig 2) were significantly related to later difficulty with vascular access. Age, weight, previous neonatal percutaneous study, and previous interventional catheterisation were not independent risk factors.

Discussion

Over 30% of previously catheterised children and adolescents present the operator with the difficulty of obtaining vascular access at subsequent catheter study. This may be due to an occluded vessel, a stenosed vessel, or scar tissue surrounding the vascular bundle. The practical implications of difficult access include prolonged access time, prolonged total catheter duration, and significant discomfort for patients being studied under local anaesthesia.

With the advent of cross sectional echocardiography the indications for cardiac catheterisation have changed; particularly fewer neonates need catheter study to provide accurate diagnosis. Despite this, advances in cardiac surgery and interventional techniques mean that some children continue to need repeat catheterisation; these include patients

with prolonged survival after complex repair (for example, staged operations for pulmonary atresia with ventricular septal defect and aortopulmonary collaterals) and those who need catheter based interventions (for example, balloon dilatation of venous pathway obstructions after a Mustard procedure).

We have identified two groups of children and adolescents with a high risk of difficult vascular access; those who have previously had cut down procedures as neonates and those who have had multiple previous catheter studies. All cut down procedures were routinely performed on the saphenous rather than the femoral vein, usually, however, only after prolonged attempts at percutaneous vein cannulation had failed. It may be that the vein was damaged during the percutaneous attempts rather than by the cut down procedure itself, or that the cut down resulted in scarring around the vessels, which caused later access difficulties, rather than a blocked vessel. In practical terms however, difficulty was found in two thirds of cases after previous cut down procedures, and so these sites should be avoided. By contrast, where percutaneous femoral vein puncture was successful in a neonate, the vein tended to be patent for later study, even after a balloon septostomy had been performed.

Multiple previous procedures also predisposed to later access problems. Such children have almost always had cardiac surgery, spent time in an intensive treatment unit, and often had indwelling catheters in the femoral vessels; this may be a confounding factor. No patients in the study group had had a previous femorofemoral bypass. We were unable to analyse the incidence of previous femoral cannulation for perioperative monitoring as the site of central lines is not consistently recorded in the case notes. Whatever the aetiology, children in these categories should probably be catheterised under general anaesthesia in anticipation of difficulties with vascular access.

Access to the femoral vein was more difficult than to the artery. Venous thrombosis after catheterisation is a well recognised complication.³⁻⁸ This may be related to larger catheters being used in the vein with slower venous flow or to the frequent practice in paediatrics of catheter study not requiring arterial catheterisation but only needle puncture (if the left heart can be reached through a septal defect or patent foramen ovale). Keane *et al* have previously documented a 4% incidence of occlusion of the iliac vein or inferior vena cava after a single catheterisation of the femoral vein in children under six months of age⁹; as in our series, neither age, weight, duration of catheter, nor use of balloon catheters were risk factors for late venous thrombosis. In our study there were also a few cases of difficult arterial access, despite routine use of heparin for previous arterial studies.¹⁰ Arterial occlusion is well recognised after both diagnostic¹¹⁻¹³ and interventional¹⁴⁻¹⁶ studies in children. The judicious use of streptokinase for absent leg pulses after

a catheter, however, may minimise the incidence of this complication in the future.¹⁷

As more children and young adults with congenital heart disease survive long enough to need surgery or catheter interventions, invasive study of these subjects will provide challenges to obtain adequate vascular access. Procedures of current practice, such as avoiding cut downs, careful cannulation of the vessel, and meticulous use of heparin and streptokinase when indicated may minimise the incidence of difficulties of late vascular access. We currently suggest avoiding the site of previous cut down procedures and the use of general anaesthesia for studying children and adolescents who have been previously catheterised on two or more occasions.

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